

# Idaho National Engineering and Environmental Laboratory

## ***CYANIDE DEGRADATION IN TAILINGS PONDS BY STIMULATING INDIGENOUS MICROORGANISMS***

Process waters generated during the mining and processing of minerals often contain toxic components that need to be treated before reuse or discharge to the environment. These can include cyanide, sulfates and metals. The treatment of these contaminated waters is cost intensive and can lead to prolonged mine closure costs. Chemical procedures or natural attenuation can be employed to degrade some of these toxic components. These procedures are expensive and, in some cases, involve long periods of time. Biological degradation by stimulating naturally existing, indigenous microorganisms can be less expensive than chemical methods and faster than natural attenuation. This allows for less treatment time and cost for water reuse (such as for biooxidation heaps) or for discharge of effluent streams to the environment. Many biological processes require nutrient additions, including phosphorous. The addition of phosphorous as phosphate to process waters with metals often results in precipitation and loss of biologically available phosphorous. Addition of supplemental nutrients to existing tailings ponds (including biologically

available phosphorous) can stimulate indigenous microorganisms and result in inexpensive water treatment.

### ***Statement of Problem and Technology Concept***

Cyanide compounds are commonly used in various industries including gold mining and electroplating. The resulting effluent contains cyanide, heavy metals (cyano-metal complexes), weak acid dissociate cyanides (WAD) and thiocyanate. Due to high toxicity, water contaminated with cyanide and heavy metals must be treated before reuse or released to meet regulatory requirements.

***Objective:*** The objective of this work is to stimulate naturally existing, indigenous microorganisms to degrade cyanide in effluent streams for discharge to the environment, or for water reuse, such as for biooxidation heaps. Stimulation of indigenous microorganisms using the most cost effective nutrients is an inexpensive method to initiate or increase degradation of cyanide to supplement natural attenuation or chemical treatment. Biodegradation of cyanide by microorganisms isolated from mine environments has been widely reported in laboratory

settings. Large-scale bioreactors have also been used to accomplish bioremediation of cyanide effluent waste. However, large-scale bioreactors can be expensive and sometimes cannot treat the throughput efficiently. Stimulation of indigenous microorganisms for waste degradation is a common technology. Nitrogen, phosphorus, carbon or trace elements in the natural environment frequently limit microorganisms. In past studies carbon and phosphorous have been added to enhance bacterial cyanide degradation. However, others have isolated bacteria that use cyanide as a carbon source. One problem that past studies have shown was precipitation and solubility issues with phosphate addition. A complexed phosphate that will be bioavailable will be used in this work.

***Projected Outcome:*** This work will determine if indigenous microbial populations can be stimulated at a test site and what additional nutrients (carbon and/or phosphorus source) may be needed for growth and their effectiveness. If cyanide-degrading microorganisms are present at the test site, an

attempt will be made to stimulate them in both a small section of a tailings pond and in a tank filled with both solids and liquids from the tailings pond. Enhancement of indigenous microbial populations is expected to produce higher rates of cyanide degradation as compared to natural attenuation. This is important in cold climate conditions at higher elevations where only 5-6 months of effective treatment time can be expected. By obtaining faster degradation rates, the water could be reused for other applications at a mine or more water could be discharged from the mine site, resulting in decreased holding times of both the water and the property. This technology could be used along with chemical methods such as peroxide treatment, alkaline chlorination, activated charcoal, etc., or even replace chemical methods entirely. The Idaho National Engineering and Environmental Laboratory (INEEL) has over 15 years of experience in the field of biohydrometallurgy. INEEL scientists have performed fundamental studies on the major classes of acidophilic bacteria in acidic mining environments for over a decade. Much of this work supported U.S. Bureau of Mines (USBM) programs in biological leaching of sulfide minerals, and also the Bureau of Mines in-situ mining program. Other work has included biosorption of metals, biological remediation of acid rock drainage and selenium-laden streams, and

studies on cyanide degrading organisms. The multidisciplinary composition of the Biotechnology Department at the INEEL provides team members with expertise ranging from microbiology, biochemistry, molecular biology, and biochemical engineering. Virtually all members of the project team have participated in mining-related projects for the USBM and various mining companies. Recent industry sponsored work and internally funded projects have focused on optimization of biologically mediated chalcopryite heap leaching.

### ***Environmental and Economic Benefits***

There are two potential environmental benefits from this work. One is the more timely remediation of cyanide in tailings ponds or waters, especially in colder environments. Some mines only have around 5-6 months out of the year to try to remediate their process water due to the freezing conditions during the rest of the year. They usually rely on natural attenuation or chemical methods during the summer months to lower the cyanide concentrations in their tailings ponds. The cyanide concentration in the ponds is not low enough to either reuse or discharge the water, so the mines wait until the next summer to continue remediation, so that the cyanide concentration meets National Pollutant Discharge Elimination System (NPDES) discharge limits. Current practices may require up to five years before water can be

reused or discharged. Stimulating indigenous bacteria should increase the destruction of cyanide complexes, thus decreasing the amount of time a mine will have to treat the water. The bioremediation process could be used in conjunction with chemical methods if desired. The other potential environmental benefit is the reuse of the water for other applications. The extent of remediation resulting from indigenous bacteria stimulation may be such that some of the water may be available to use in other processes. For example, in arid climates like Nevada and Arizona, water reuse is paramount, and water that has been treated could be reused in a bioleaching circuit. The economic benefits would be: 1) Reduced property holding costs resulting from shorter water treatment time, 2) reduced aeration costs, 3) less chemical and operation costs associated with chemical methods (if used in conjunction with the bioremediation), and 4) potentially lower disposal costs if the water is reused.

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